Social Science & Medicine 223 (2019) 40–50

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Conceptualizations of climate-related health risks among health experts and the public in Ghana

Lucia Kafui Hussey*, Godwin Arku

Department of Geography, Western University, London, ON N6A 5C2, Canada

ARTICLE INFO

Keywords:
Ghana
Climate change
Climate change knowledge
Climate-induced health problems
Health risk perception
Public health

ABSTRACT

One major area that has gathered public attention in relation to climate change is health risks. Studies into risk perceptions have acknowledged differences between public and expert knowledge. What is less known is how perceptions of climate change related health risk vary between the public and health experts and how these differentiated perceptions are shaped and modified by everyday complex climate change narratives from multiple actors, and contextual ecologies of social and physical spaces. A concurrent mixed-methods approach was used to elucidate climate change knowledge and awareness of climate-related health risks among health experts and the public. Qualitative and quantitative data were collected on community members (n = 927) and health experts (n = 99) in Savelugu-Nanton and Ada East Districts in Ghana. The results showed that both groups were likely to report climate change-related health concerns, of which disease was the top concern. However, differences exist in public and experts' perceptions of climate change health linkage. Community members were less likely to link climate change to health risks compared with health experts (OR = 0.02, $p \leq 0.000$). The contrasting climate change health risk perceptions between health experts and the public adds to the literature on the health dimensions of global environmental change. The findings from this study highlight limited knowledge about climate change health related risks among the public. Hence, in building sustainable communities in light of persistent climate change impacts, it is crucial to improve climate change adaptation by implementing climate change sensitization programs. In addition, health infrastructure, decision-making and management should be strengthened for effective response to emerging climate-health risks in Ghana and similar contexts.

1. Introduction

Climate change is arguably one of the most pressing environmental challenges in recent history. Currently, the impact of climate change on human health has garnered public and policy attention. The health effects of climate change comprise changes in the prevalence and spread of infectious diseases, geographic expansion and range shifts in disease distributions, projected increases of vector-borne and diarrhoeal diseases, emergence of new infectious diseases and re-emergence of old ones (Costello et al., 2009; IPCC et al., 2014; WHO, 2008). The World Health Organization (WHO) has suggested that between 2030 and 2050, climate change impacts are expected to cause approximately 250,000 deaths per year, largely from malnutrition, malaria, diarrhoea, dengue, coastal flooding and heat stress (WHO, 2014). Furthermore, climate changes are contributing to the emergence of infections carried by mosquitoes such as Zika and Chikungunya (Asad and Carpenter, 2018). A 2018 Lancet report also highlighted that altered climatic conditions are contributing to growing vectorial capacity for the transmission of dengue fever by *Aedes aegypti* of 3% higher compared with 1990 levels, and 9.4% higher compared with 1950 levels (Watts et al., 2018). Watts et al. (2018) further report about an increasing exposure to frequent and more intense heat waves; it is estimated that between 2000 and 2016, the number of vulnerable people exposed to heat wave events increased by about 125 million, with a recorded 175 million more people exposed to heatwaves in 2015. With these projected and current risks, climate change has been emphasized as a significant threat to public health and likely, the most pressing problem of the 21st century (WHO, 2009; Costello et al., 2009; Watts et al., 2018). The projected impacts of climate change on health will not only burden human populations, but also health systems.

Climate change adaptation has emerged as a key strategy, often employed to cope with anticipated climate change risks (IPCC et al., 2014). However, there are questions about the extent to which local populations understand climate change information provided by

* Corresponding author.
E-mail address: lhussey3@uwo.ca (L.K. Hussey).

https://doi.org/10.1016/j.socscimed.2019.01.026
Received 8 May 2018; Received in revised form 16 December 2018; Accepted 15 January 2019
Available online 18 January 2019
0277-9536/ © 2019 Elsevier Ltd. All rights reserved.

multiple stakeholders, and their capacity to utilize such information in developing sustainable climate change adaptation mechanisms within their socio-cultural spaces. As suggested by Capstick et al. (2015) and Shi et al. (2016), knowledge and awareness of climate change and its consequences are important in developing adaptation strategies against its potential risks. Yet, understanding climate change information and translating it into actionable mechanisms has been a major challenge. Yu et al. (2013) acknowledge this challenge as a major barrier to the development of climate change knowledge and adaptation among local populations in China. In furtherance of this, other studies have explained peoples' adaptive behaviour as a reflection of their knowledge, perceptions, and attitudes towards climate change risks (Baptiste, 2017; Rudiak-Gould, 2012). Thus, knowledge and awareness of climate-related health effects is crucial in building adaptation against health risks.

In recent years, some researchers have assessed public perceptions of climate-related health risks (e.g., Cardwell and Elliott, 2013; Dana et al., 2015; Kabir et al., 2016; Maibach et al., 2015), while others have extended the analysis to compare lay persons and experts' perceptions of the causes of climate change and risk assessment. For instance, Weber and Stern in their 2011 study in the United States found disparities in climate change knowledge between lay persons and experts. They assert that lay people's mental models of climate change and its causes often diverge from those of experts (Weber and Stern, 2011). Studies into risk perceptions have also acknowledged differences between public risk assessment compared to those of professionals, scientists and experts (Hansen et al., 2003; Kellstedt et al., 2008). Although studies on climate change risk perception are prevalent in the literature, few have contrasted the views of health practitioners and the general public (Hathaway and Maibach, 2018).

Thus, the main purpose of this study is to examine knowledge and awareness of climate-related health risks in Ghana, comparing the views of health experts and the general public. For developing countries like Ghana, climate change-health risks are of concern. Currently, the Ghanaian population is projected to carry a greater burden and risk being overwhelmed with multiple health issues (Costello et al., 2009). Despite Ghana's vulnerability to climate-related health risks, studies that have assessed public knowledge and perceptions of climate change health linkages are limited (Codjoe and Nabie, 2014; Codjoe and Larbi, 2016). The goal of this study is to provide a nuanced understanding of perceptions of climate change-health linkages between health experts and the public in Ghana. In our investigation, we aim to answer the following research questions:

1. What are the perceptions of climate-related health risks in Ghana?
2. How do these perceptions differ between health experts and the general public?
3. What factors predict perceptions and knowledge of climate-related health risks in Ghana?

The research questions are examined using both quantitative and qualitative data from investigation carried out in two different ecological zones in Ghana. The rest of the paper is organized as follows: in the next section, we briefly present an overview of the conceptual dimensions as they relate to climate change risk perception, the study area and methodology, followed by the study findings, discussion, and conclusion.

2. Theoretical framework: predictors of climate change risk perceptions

Knowledge of climate-related health risks are important for health practice and climate change policy, such as designing effective climate change health risk communication strategies. According to Read et al. (1994: 971), "risk communication will be most successful and efficient when it is directed toward correcting those knowledge gaps and misconceptions that are most critical to the decisions people face." Perceived risk has a prominent role in health behavior theories and interventions. Several theories have been proposed to explain why different individuals make dissimilar approximations of the danger of risks. Risk perceptions of climate change are complex and influenced by a multitude of cognitive, affective, social, cultural, and socio-demographic factors (Helgeson et al., 2012). In line with these conceptual dimensions, van der Linden (2015) advanced a detailed social-psychological model of climate change risk perception by combining and integrating them. The model termed Climate Change Risk Perception Model (CCRPM) integrates four conceptual dimensions in explaining and predicting holistic risk perceptions of climate change. These dimensions are cognitive, experiential, socio-cultural and socio-demographic. Drawing from the cognitive and the socio-demographic dimensions identified to be critical in explaining public risk perceptions of climate change from the CCRPM, this study evaluates the extent to which these dimensions predict perceptions of climate change as a health risk in two districts in Ghana.

van der Linden (2015) suggests that, to estimate the probability with which climate change is likely to occur and the severity of accompanying consequences, some knowledge of these factors must be first acquired. The cognitive dimension of climate change risk perception considers the fact that if an individual has no awareness about the climate change problem, then they are unlikely to form a judgement about it (van der Linden, 2017). Thus, knowledge about climate change is regarded as a cognitive aspect of risk judgments (Sundblad et al., 2007). Lee et al. (2015) have reported that understanding climate change as human-caused was an important predictor of public risk perception worldwide. Shi et al. (2016) found that different forms of climate change knowledge were significant predictors of climate change risk perceptions across continents. Other studies (Kellstedt et al., 2008) have also provided counter arguments, suggesting knowledge to be negatively associated with risk perceptions of climate change. Knowledge under the cognitive dimension can be measured in different ways: public knowledge about the causes, impacts, and responses to climate change (van der Linden, 2015). Within this current study, knowledge about the causes of climate change is measured.

In the climate change risk perception literature, there has been mixed evidence regarding the extent to which socio-demographic and social-structural factors account for climate change risk perception (van der Linden, 2017). For instance, even though some studies found that higher education predicts stronger risk perceptions of climate change (e.g., Lee et al., 2015; van der Linden, 2015), other studies reported no education-effect (Akerlof et al., 2013; Kellstedt et al., 2008; O'connor et al., 1999). Results also vary by age, with some studies revealing a negative correlation between age and climate change risk perception (Kellstedt et al., 2008; Milfont, 2012), while others find no significant relationship (O'connor et al., 1999; Sundblad et al., 2007). It has also been documented that females tend to have higher risk perceptions than males regarding climate change (e.g., O'connor et al., 1999; Sundblad et al., 2007). Despite the mixed evidence regarding socio-demographic and social-structural factors, gender, political ideology and race have been identified as stable predictors of risk perception. Drawing insights from these previous studies, some theoretically relevant socio-demographic factors are evaluated in this study to determine their influence on perceiving climate change as a health risk in Ghana.

3. Study setting

The geographical focus of this study is the Savelugu-Nanton and Ada East Districts in Ghana that are located in different ecological zones (the northern and southern parts of Ghana), and experience different climatic conditions. The Savelugu-Nanton Municipality is located in the northern part of Ghana's Northern Region. It shares boundaries with West Mamprusi to the North, Karaga to the East, Kumbungu to the West and Tamale Metropolitan Assembly to the South. The Municipality has

Table 1
Key facts of study districts.
Source of information.

	Savelugu-Nanton Municipal	Ada East District
Population	139,283	71,671
Total Land Area	2022.6 sq. km	289.783 sq. km
Rural Urban Status	60% rural	68.3% rural
Climate	Average annual rainfall of 600 mm which sometimes rises to 1000 mm. High temperatures with average temperature of 34 °C, a maximum of 42 °C and a minimum as low as 16 °C (The low temperature is experienced during harmattan)	Rainfall is normally heavy with average of about 750 mm Temperatures are high throughout the year. Ranges between 23 °C and 28 °C with a maximum temperature of 33 °C (attainable during hot seasons). Area very dry during the harmattan season when there is no rainfall. Humidity is about 60 percent high due to water bodies around.
Vegetation	The municipal is in the Savanna woodland which could sustain large scale livestock farming, as well as the cultivation of food crops such as rice, groundnuts, yams, cassava, maize, cowpea and sorghum	The vegetation is basically the coastal savannah type, characterized by short savannah grasses and interspersed with shrubs and short trees. Along the coast, there are stretches of coconut trees and patches of coconut groves. A few strands of mangrove trees can be found along the tributaries of the Volta River where the soil is waterlogged and salty.
Top 10 Diseases 2015 *(listed in order of magnitude)*	Malaria, Upper Respiratory Tract Infection, Anaemia, Pneumonia, Urinary Tract Infection, Diarrhea, Hypertension, Joint pains, and skin diseases ****	Upper Respiratory Tract Infection, Malaria, Diarrhoea, Rheumatism & Joints Pain, Skin Diseases, Intestinal Worms, Acute Urinary Tract Infection, Anaemia, Acute Eye Infections, Septicaemia. ***
Health Facilities	14 Operational Community-Based Health Planning and Service (CHPS) zones, 12 CHPS compounds, 3 Health Centers, 5 Clinics, and a District Hospital **	8 CHPS facilities, 3 Health Centers, 1 Clinic, and a District Hospital***

All others: Ghana Statistical Service 2014, (2010 Population and Housing Census District Analytical report for Ada East District and Savelugu-Nanton Municipal).
** Savelugu-Nanton Municipal Assembly (2018).
***Data from the Ada East District Assembly (2018).
**** Data obtained from Savelugu-Nanton District Hospital (Field research, 2016).

a total land area of about 2022.6 km^2 with a population density of 68.9 persons per km^2 (Ghana Statistical Service, 2014a). The Ada East District on the other hand, is situated within the eastern part of Ghana's Greater Accra Region (southern part), with a total land area of 289.783 km^2. The District shares boundaries with the Central Tongu District to the North, South Tongu District and Ada West to the East and West respectively. It is also bounded by the Volta River south–-eastwards, extending to the Gulf of Guinea southwards (Ghana Statistical Service, 2014b). Key facts about each of our study districts are presented in Table 1.

Seasonal variations in temperature in Ghana are greatest in the northern part of the country, with highest temperatures in the hot, dry season (February to May) averaging 27–32 °C, while the lowest (25–27 °C) is recorded in July through September. However, in the southern part of the country, temperatures range between 22 °C to 28 °C (McSweeney et al., 2012; Stanturf et al., 2011). Rainfall variability increases in the north, while rainfall amount decreases from the southern to the northern part of the country. The wettest zone is the southwest corner of the country, where annual rainfall reaches 2000 mm. In contrast, the annual rainfall in the dry savannah zone in the northern part of the country is well below 1100 mm (EPA, Ghana, 2012). Recent projections of climate change impacts in Ghana vary between the southern and northern parts of the country (McSweeney et al., 2012; Stanturf et al., 2011). National mean annual temperature is projected to increase by 1.0–3.0 °C in the 2060's, and 1.5–5.2 °C in the 2090's (McSweeney et al., 2012). The northern part of the country is expected to experience more dire impacts. For instance, the rate of warming is projected to rise more rapidly in this zone than the coastal regions (McSweeney et al., 2012). These variations in climatic conditions and projections are likely to have different implications for health outcomes, thus influencing the choice of districts from both sectors of the country for this study. In addition, the selection of districts from different geographical zones in Ghana helps to account for any potential 'differentiated' perspectives on the links between climate change and health within the country. Curtis and Oven (2012) have advocated for such a perspective to help in capturing diverse factors that might induce health vulnerabilities and affect resilience towards climate change among individuals.

4. Methodology

This study uses data collected through a concurrent mixed-method research design (Bryman, 2006). A quantitative approach (surveys) and qualitative approach (face-to-face in-depth interviews) are used to address overlapping but also different facets of climate change and its health linkages, as well as to enrich and deepen our understanding of the complexities of the linkages (Creswell, 2014). The study protocol was approved by the authors' institution and in Ghana by the Health Service Ethical Review Committee. All research participants provided either oral or written consent.

4.1. Data collection

The sample was drawn from the adult population residing in both districts and comprised of individuals aged 18 years and above. Total respondents of the study consist of 1026 individuals (i.e., n = 99 health practitioners; n = 927 community members). The overall sample consists of 526 males and 500 females, with age ranging between 18 and 70 years. The study employed a two-staged stratified sampling framework (Onwuegbuzie and Collins, 2007) in recruiting community members. The population was grouped into two strata (urban and rural) based on Ghana Statistical Service's definition of rural areas (population less than 5000) (Ghana Statistical Service , 2015). Simple random sampling was used to select study communities and households from them for interviews. For health practitioners, government health institutions within both study districts were identified, and public health practitioners were sampled from them and interviewed.

Qualitative interview respondents were purposively selected from the larger quantitative survey sample. Qualitative data were collected to a point of saturation, after which the themes already captured were being repeated in subsequent interviews (Creswell, 2014). Interviews consisted of semi-structured questions that allowed for exploration of new ideas in every new interview. Participants were asked to describe and reflect on climate change, impacts and links to health and any potential health implications they know. Participants in qualitative interviews include 68 individuals (health experts, n = 20; community members, n = 48). The overall sample consists of both males (n = 45)

Table 2
Distribution of cause of climate change (underlying cause) and linking climate change with health by compositional and contextual factors.

	Cause			Health link		
	Non-Factual Knowledge (%)	Factual Knowledge (%)	Statistics X^2(df), Cramer's V)	No link (%)	Link (%)	Statistics X^2(df), Cramer's V)
Group			(1) = 11.4577	2 (2)	95 (98)	(1) = 95.4156
Health expert	25 (26)	72 (74)	Pr = 0.001	498 (54)	419 (46)	Pr = 0.001
Community member	399 (44)	516 (56)	Cramer's V = −0.1064			Cramer's V = −0.3071
Cause of climate change						(1) = 25.1498
Non-Factual knowledge				248 (58)	176 (41)	Pr = 0.000
Factual knowledge				250 (43)	338 (57)	Cramer's V = 0.1576
Compositional Factors						
Gender			(1) = 19.4569	206 (40)	311 (60)	(1) = 37.0833
Male	182 (35)	335 (65)	Pr = 0.000	292 (59)	203 (40)	Pr = 0.000
Female	242 (49)	253 (51)	Cramer's V = −0.1387			Cramer's V = −0.1914
Age						
18-30	147 (36)	259 (64)	(4) = 27.4310	181 (45)	225 (55)	(4) = 10.6510
31-40	135 (46)	158 (54)	Pr = 0.000	150 (51)	143 (49)	Pr = 0.000
41-50	73 (37)	123(63)	Cramer's V = 0.1646	111 (57)	85 (43)	Cramer's V = 0.1026
51-60	44 (53)	39 (47)		36 (43)	47 (57)	
61 +	25 (74)	9 (26)		20 (59)	14 (41)	
Educational Status						
No Education	227 (52)	208 (48)	(3) = 43.4186	283 (65)	152 (35)	(3) = 110.6197
Primary	69 (44)	88 (56)	Pr = 0.000	70 (45)	87 (55)	Pr = 0.000
Secondary	74 (33)	147 (67)	Cramer's V = 0.2071	104 (47)	117 (53)	Cramer's V = 0.3306
Tertiary	54 (27)	145 (73)		41 (21)	158 (79)	
Religion						
Christian	177 (35)	331 (65)	(2) = 20.9644	199 (39)	309 (61)	(2) = 41.8782
Muslim	244 (49)	253 (51)	Pr = 0.000	296 (60)	201 (40)	Pr = 0.000
Traditional	3 (43)	4 (57)	Cramer's V = 0.1439	3 (43)	4 (57)	Cramer's V = 0.2034
Ethnicity						
Dagbani	252 (50)	254 (50)	(4) = 29.6594	310 (61)	196 (39)	(4) = 69.2302
Dangbe	121 (37)	209 (63)	Pr = 0.000	137 (42)	193 (58)	Pr = 0.000
Ewe	22 (33)	45 (67)	Cramer's V = 0.1712	18 (27)	49 (73)	Cramer's V = 0.2616
Akan	15 (25)	46 (75)		14 (23)	47 (77)	
Others	14 (29)	34 (71)		19 (40)	29 (60)	
Marital Status						
Never married	113 (31)	248 (69)	(2) = 26.2713	141 (39)	220 (61)	(2) = 23.4947
Currently married	292 (47)	323 (53)	Pr = 0.000	339 (55)	276 (45)	Pr = 0.000
Formerly married	19 (53)	17 (47)	Cramer's V = 0.1611	18 (50)	18 (50)	Cramer's V = 0.1524
Occupation						
Health Professional	25 (26)	72 (74)	(6) = 45.0161	2 (2)	95 (98)	(6) = 133.7186
Unemployed	38 (40)	58 (60)	Pr = 0.000	38 (40)	58 (60)	Pr = 0.000
Agricultural Activities	217 (50)	216 (50)	Cramer's V = 0.2109	271(63)	162 (37)	Cramer's V = 0.3635
Business (Trading)	69 (49)	73 (51)		82 (58)	60 (42)	
Services (Gov't & NGOs)	22 (24)	69 (76)		33 (36)	58 (64)	
Student	8 (20)	32 (80)		23 (57.5)	17 (42.5)	
Others	45 (40)	68 (60)		49 (43)	64 (57)	
Contextual Factors						
Residential Locality			(1) = 7.2591			(1) = 10.3962
Urban	142 (37)	246 (63)	Pr = 0.007	166 (43)	222 (57)	Pr = 0.001
Rural	282 (45)	342 (55)	Cramer's V = −0.0847	332 (53)	292 (47)	Cramer's V = 0.1014
Region			(1) = 26.9216			(1) = 37.2476
Northern	271 (49)	279 (51)	Pr = 0.000	319 (58)	231 (42)	Pr = 0.000
Greater Accra	153 (33)	309 (67)	Cramer's V = 0.1631	179 (39)	283 (61)	Cramer's V = 0.1918

and females (n = 23), with ages ranging from 25 to 65 years.

4.2. Quantitative analysis

Climate change knowledge is of different forms and consists of either an individual's 'subjective' knowledge (i.e., what people think is true) and the actual 'evidence'. It is assessed either subjectively (self-reported knowledge) or objectively ('accurate' knowledge people hold about climate change). Climate change knowledge evaluated includes public knowledge about the causes, impacts, and responses to climate change (van der Linden, 2015).

In this study, objective knowledge about climate change was measured because it provides useful connections to policy on health-related risks of climate change (Kahlor and Rosenthal, 2009). Climate change knowledge is conceptualized as knowing the underlying cause of climate change. Lee et al. (2015) indicate that understanding the cause of climate change is the strongest predictor of climate change risk perceptions.

4.2.1. Dependent variable

"Cause of climate change" and "health link" were the dependent variables used to evaluate the public and health experts' perceptions and knowledge on climate change and its health implications. Cause of climate change was derived from the question: what is the single most important cause of climate change? The response categories were deforestation, overpopulation (births and immigration), greenhouse gas emissions, resource extraction, God's will, violating/transgressing cultural values and norms, and don't know. Responses were categorized into two, with greenhouse gas emissions, resource extraction and deforestation coded as "1" (factual knowledge of causes of climate change) and the others combined and coded "0" (non-factual knowledge of causes of climate change) because they constitute incorrect

Table 3
Logistic regression models for cause of climate change, linking climate change with health and compositional and contextual factors.

	Perceived Cause of Climate Change						Health Linkage								
	Model 1			Model 2			Model 1			Model 2			Model 3		
	Cause of Climate Change			Compositional & Contextual factors			Health link			Cause of Climate Change			Compositional & Contextual Factors		
	OR	P > z	[95% CI]	OR	P > z	[95% CI]	OR	P > z	[95% CI]	OR	P > z	[95% CI]	OR	P > z	[95% CI]
Group (ref: Health practitioner)															
Community member	0.45	**0.001**	0.280, 0.721	0.74	0.359	0.384, 1.414	0.02	**0.000**	0.004, 0.073	0.02	**0.000**	0.005, 0.077	0.02	**0.000**	0.005, 0.094
Cause of climate change (ref. Non-factual knowledge)															
Factual knowledge										1.75	**0.000**	1.342, 2.284	1.51	**0.006**	1.127, 2.012
Gender (ref: Male)															
Female				0.70	**0.011**	0.526, 0.919							0.50	**0.000**	0.375, 0.677
Age groups (ref: 18–30 years)															
31–40				1.18	0.442	0.770, 1.823							1.35	0.192	0.861, 2.103
41–50				2.10	**0.004**	1.265, 3.472							1.45	0.151	0.873, 2.415
51–60				1.01	0.967	0.554, 1.850							2.42	**0.004**	1.332, 4.412
61 +				0.37	**0.031**	0.150, 0.914							1.39	0.394	0.651, 2.979
Educational Status (ref: No Education)															
Primary				1.05	0.855	0.645, 1.695							1.88	**0.015**	1.130, 3.116
Secondary				1.46	0.131	0.894, 2.373							1.54	0.101	0.920, 2.567
Tertiary				1.90	**0.032**	1.058, 3.402							2.08	**0.014**	1.157, 3.736
Religion (ref: Christian)															
Muslim				1.16	0.646	0.624, 2.138							1.62	0.178	0.803, 3.259
Traditional				1.15	0.891	0.165, 7.952							1.46	0.606	0.347, 6.133
Ethnicity (ref: Dagbani)															
Dangbe				0.45	0.112	0.170, 1.205							4.64	**0.018**	1.299, 16.555
Ewe				0.51	0.214	0.177, 1.475							7.72	**0.006**	1.823, 32.676
Akan				0.67	0.461	0.233, 1.935							2.73	0.171	0.649, 11.468
Others				1.14	0.747	0.524, 2.464							2.37	0.080	0.902, 6.255
Marital Status (ref: Never Married)															
Currently married				0.68	0.101	0.431, 1.078							0.99	0.973	0.622, 1.582
Formerly married				0.75	0.493	0.323, 1.726							1.27	0.589	0.536, 2.998
Urbanicity (ref: Urban)															
Rural				0.95	0.750	0.702, 1.290							1.12	0.509	0.804, 1.553
Region (ref: Northern Region)															
Greater Accra				3.31	**0.008**	1.375, 7.976							0.56	0.364	0.164, 1.943
Total =					1012				= 1012						
Log Pseudo-likelihood =					−588.16,764				= −588.16,764						

beliefs about the cause of climate change. The response categories classified as factual knowledge have been shown to have scientific contributions to climate change. Greenhouse gases have been established in the literature as the major contributor to climate change (Read et al., 1994, IPCC et al., 2014). Deforestation and resource extraction also contribute in a modest way through emission of greenhouse gases, removal of carbon sinks, and changes in albedo which are changing the concentration of atmospheric constituents (Bord et al., 2000; Haines, 2012; IPCC et al., 2014; Read et al., 1994). With knowledge being a significant predictor of risk judgments, we hypothesize based on previous literature that factual knowledge of the cause of climate change will strongly predict perceptions of climate change as a health threat.

The "Health link" variable, which looks at perception of climate change as a health threat was created from the question: "Do you think there is a link between climate change and health?" Yes was coded "1" (health link) and No coded "0" (no health link).

4.2.2. Independent variable and controls

The key independent variable was group (health expert vs. public). It is documented that climate change knowledge and risk perception varies with socio-demographic and social-structural factors. Wolf and Moser (2011) argued that positionality in society as indicated by gender, age, socioeconomic status, and other social variables plays an important role in differentiated judgments of climate change by various groups. These socio-demographic and social-structural factors have been grouped into compositional (Hartter et al., 2012) and contextual factors (Lee et al., 2015). According to Pol and Thomas (2013), compositional factors are made up of: 1) biosocial characteristics that encompass biological and physical components including age, gender, ethnicity; and 2) sociocultural factors which reflect positions of individuals in the social structure and include factors such as marital status, education, occupation, and religion among others. Contextual variables refer to the broader social and physical opportunities in a region, such as availability of and access to services: broader place specific characteristics (Collins et al., 2017). These theoretically relevant determinants were included in the analysis to discover their predictive values on objective knowledge of climate change and climate change health risk perception.

4.2.3. Quantitative data analysis

The analytic sample was 1012 individuals who answered all the climate change knowledge questions. STATA 14SE software was used in data analysis. The analysis presented in Table 2 shows Chi-square and Cramer's V statistics for the relationship between the two dependent variables and independent variables. In addition, a multivariate logistic regression analysis was performed to estimate the relationship between the outcome variables ('cause of climate change' and 'health link') and key independent variable – Group-health expert vs. public. Logistic regression was employed for the statistical analysis due to the dichotomous nature of our dependent variables.

4.3. Qualitative data analysis

Recorded in-depth interviews were translated into English and transcribed verbatim for analysis. To allow continued immersion in the field data, the analysis was manually conducted using hand coding which involved reading and re-reading the transcripts and associated field notes, and coding important texts (Luginaah et al., 2010; Miles et al., 2014). Codes were developed and organized according to emergent themes.

5. Results

5.1. Quantitative findings

5.1.1. Knowledge of underlying cause of climate change

The results from multivariate logistic regression models are presented in Table 3. The analysis showed that the public have a lower odds of reporting factual knowledge of the underlying cause of climate change compared to health experts in model 1 (OR = 0.45, $p \leq 0.001$). However, when compositional and contextual factors (collective effect) are included, the statistically significant relationship disappears. Further analysis revealed both ethnicity and educational status completely moderated the relationship. For compositional factors, gender, age and educational status were found to predict factual knowledge of the underlying cause of climate change. Females were 30% less likely to have factual knowledge of the underlying cause of climate change compared to males. Compared to the age group 18–30, respondents aged 41–50 were found to be more likely (OR = 2.10, $p \leq 0.004$), while respondents 61 years and older were less likely (OR = 0.37, $p \leq 0.031$) to have such knowledge. For contextual variables, region of residence was a significant predictor of factual knowledge of the underlying cause of climate change. Residents in the Greater Accra Region have significantly higher odds of reporting factual knowledge of the underlying cause of climate change relative to their counterparts in northern Ghana (OR = 3.31, $p \leq 0.008$).

5.1.2. Perception of climate-related health risks

In Table 3, results from three multivariate models explaining the relationship between climate change-health link and the independent variable are presented. Model 2 controls for knowledge of cause of climate change, and Model 3 considers compositional and contextual variables. Taking the collective effect of all our variables into account in Model 3, community members were 98% less likely to associate climate change with health compared to health experts. Having factual knowledge of the cause of climate change was also associated with higher odds of linking climate change to health (OR = 1.51, $p \leq 0.006$). Compositional variables, including gender, age, educational level and ethnicity were found to be statistically associated with linking climate change with health. Females were 50% less likely to associate climate change with health compared to males. Compared to those between 18 and 30, individuals who are 51–60 years old had higher odds of associating climate change with health (OR = 2.42, $p \leq 0.004$). Respondents who had primary education and tertiary education were 88% and 108% respectively more likely to connect climate change with health relative to those without any formal education.

5.2. Qualitative findings

5.2.1. Contextualizing climate change-health linkages

Multiple themes emerged regarding participants' understanding of climate change and health from analysis of the in-depth interviews. The results are organized first by a theme-count table (Table 4), and then exemplary quotations that serve as low-inference descriptors for the themes identified (Miles et al., 2014). The theme-count table shows the number of participants who mentioned a given theme. Three of the most prominent themes are presented. To protect confidentiality, quotations are labeled using pseudonyms.

5.2.1.1. Climate change and health risk linkage: an individualized experience. Climate change and health linkage being a personal experience was a prominent theme among both study groups. Attributing poor health to climate change was informed by individualized conceptualizations of climate variability. Responses revealed that day-to-day experiences with climate shape views about climate change and health, especially among the public:

Table 4
Prominent themes from the in-depth interviews.
Source: Derived from in-depth interviews following analytical steps outlined by Miles et al., (2014).

Themes (Pathways for Climate Change-health link)	Theme frequencies[a]	Number of participants	
		Health experts (N = 20)	Community members (N = 48)
Climatic variability	50	14	40
Ozone depletion	5	5	
Food system changes	20	5	10
No link	5		5

[a] The number of times theme emerged in interviews.

"Yes, with the unstable temperature, we get diseases like 'catarrh' (common cold), headache and sometimes malaria. Because, we hang our mosquito nets in our rooms and at times, the room warms up to an extent that we cannot sleep there, we go out to sleep in the open resulting in us being mostly bitten by mosquitoes, and we get sick" [Yakubu (resident) Savelugu-Nanton Municipal].

"Of course, it [climate variability] does affect us, because normally all over here we are farmers. In the past, 35 years back, when we go to the farm, the weather is not that sunny so what happens is that you can be there for the whole day and farm. But this time around, when you are there especially from February to May, you will really feel the intensity of the heat. So, if you are farming, at least by 10am you must come back. But if you want to continue, maybe up to 11am or 12 o'clock, then you will be compelled to fall sick, these are problems the climate is giving us now" [Ocran (resident) Ada East District].

"Yes, we get high blood pressure and heart problems because of over thinking. Changes in the rainfall pattern cause us to over think which causes stress also. Due to changes in climate, we do not get the rains when we are supposed to and when it does rain, there is a destruction of our fields" *[Aisha (female resident) Savelugu-Nanton Municipal]*.

Other narratives connecting climate change to health were reported in the form of variability in the local food systems (supply) and its potential health risks. Low crop yield was attributable to rainfall variability and depletion of farmlands. Participants also explained how use of chemical fertilizer, which has always been presented as a solution to changing climatic conditions for farming was posing health challenges:

"The farmers, due to lack of irrigation, they will be dependent on the rainfall and the little that they will grow, the floods too will come and destroy them. If it doesn't rain too, the crops will also die. So, you will have hunger, poverty, diseases, when there is no money to buy food you can't eat and therefore your immune system will break down and definitely, you are susceptible to all kinds of diseases" [Mawuli (resident)-Ada East Municipal].

"… some time ago, farmers used not to apply fertilizer to their crops before they can get a good yield. But now if you cultivate any crop without applying fertilizer, then do not expect to make any harvest and applying the fertilizer does affect our health" [Ibrahim (resident) Savelugu-Nanton Municipal].

5.2.1.2. Climate change and health risk linkage: a learned perspective. The next prominent theme that emerged involved narratives connecting climate change to health underpinned by some level of scientific understanding. This theme, however, emerged more in the health experts' interviews, probably because they have a better understanding of the science behind climate change. They highlighted extreme radiations and release of some poisonous gases from the atmosphere which have health ramifications:

"If I should say, maybe if the ozone layer is depleted, there is a direct contact of the sun rays to the skin and it exposes you to so many infections and then damages the layers of the skin" [Health expert (public health nurse)-Ada East District].

"You know, like I know that there are some poisonous gases that are being produced in the atmosphere due to climate change, those ones too can affect the air we breathe in and with all this, it can affect our health" [Health expert-Savelugu-Nanton Municipal].

In addition, climate change and its health linkage based on climate variability was also highlighted among the health experts.

"Too much of everything is bad. For instance, when you have excessive rains that will cause flooding, it can destroy physical properties, diseases will spread, people will get infested …. On infectious diseases, malaria for instance, when you have excessive rains, mosquitoes breed a lot, so you will have a lot of malaria cases. If you have flooding, water-bodies may be contaminated with fecal matter and other things and people could have cholera. When we do not have enough rains and there is drought, people will drink from other sources of water that may not be good for their health. So, some of these waterborne diseases, the diarrhoea diseases, may not be cholera, you can have typhoid and any of the diarrhoea diseases that maybe because people did not have good water. Perhaps their water bodies are dried now, and they are drinking from other sources that normally they should not. So that is how I think" [Health expert-Ada East District].

"To me there is a risk, the management of malnutrition is a priority to me, so if there is climate change, and then we have less amount of rainfall, definitely agricultural production will be reduced. If there is not enough food in the system, certainly the people will not be able to get enough food to eat to build their nutritional status, so therefore, there will be a fall in nutritional status …" [Health expert (community health nurse)- Savelugu-Nanton Municipal].

Although both health experts and the public connect climate change to health-related risks, our analyses revealed important distinctive differences in perspectives and conceptualization of the linkage between the two groups. The study found that conceptualization of climate change-health related risks among health experts were largely underpinned by climate change scientific knowledge. Even though the health experts' conceptualization is underpinned by scientific understandings, they also demonstrated little understandings of climate change science. Some health experts conceptualized the health risks from climate change to result from release of some poisonous gases due to ozone layer depletion, which they synonymously attributed to be climate change. These views suggest that, despite their potential access to 'scientific knowledge', they have false beliefs and misunderstandings about climate change and its subsequent links to health.

In contrast, the conceptualization of the health linkage among the public happened through processes and perspectives created from personal experiences of climatic conditions in their individual social and physical spaces. As climate change and health dynamics are complex, members of the general public without training on climate change and the health consequences it poses to communities tended to rely on their individualized experiences to conceptualize and frame perspectives on climate change-health linkages.

5.2.1.3. No knowledge of climate change-health linkage. From the qualitative interviews, it also emerged that health experts were more likely to connect climate change to health than the public. This was evident from the community interviews as some members of the general public were unable to draw a link between climate change

Table 5
Perceived health concerns associated with climate change.
Source: In-depth interviews among health experts and the public.

Health Concern	Number of Participants Mentioning		
	Total	Health	Community
Changes in vector ecology	35		
Malaria		15	20
Water & food supply	17	12	5
Malnutrition		3	
Diarrhoeal disease		5	1
Cholera		3	4
Typhoid		1	
Extreme heat related illness	14	10	4
Meningitis		5	
Skin rashes (heat related)		5	4
Upper Respiratory Tract Infections	11		
Common cold		5	6
Headaches	12	1	11
Body pains	5		5

and health:

> "No, it doesn't have any impact on our health. Some people say so? Well, for me, I am not experiencing it, and nobody complains to me" [Tetteh (resident) Ada East District].

> "I do not think so, but in raining season, malaria is severe" [Adisa (resident) Savelugu-Nanton Municipal].

Some respondents also indicated they cannot say much regarding climate change and its health risks, signifying a degree of lack of knowledge on the subject:

> "Concerning our health, I cannot say anything much about it but during the farming season, I can say it affects us" [Ocansey (resident) Ada East District].

5.2.2. Climate change related health risks

Respondents perceived different health risks attributable to climate change. The prominent ones are presented in Table 5. In the interviews, participants repeatedly mentioned health concerns related to changes in vector ecology (35 mentions) with malaria mostly coming top. This could be due to the malaria parasites sensitivity to climate variability (Ermert et al., 2012) and its endemic nature in Ghana.

The second health concern that emerged was related to food and water supply shortage. Participants in the interviews report declining crop yields and water shortage due to extreme variability in the rainfall pattern. Such variability triggers rising temperatures, droughts, and floods, with cyclical impacts on food production and water availability for household consumption. These climate induced conditions tended to compromise food security and safety leading to health-related issues. Health experts were more likely to name health concerns related to this theme compared to the public. Malnutrition due to shortage in food supply or food security, food and water borne diseases such as diarrhoeal, typhoid and cholera were mentioned.

Extreme heat related health concerns or illnesses such as skin diseases or heat related rashes were reported as one of the major climate change related health risks to local populations. Respondents identified temperature variability as the main climatic condition responsible for skin diseases. One health expert (public health nurse) expressed concern over this during an interview:

> "I remember somewhere last year, most people were complaining of itching, severe itching all over. After the person exposes themselves to the sun and gets indoors the itching starts. Immediately there was a change in weather, when the rainy season set in then it normalized. So, don't you think is the climate"? [Agnes (health expert) Ada East District].

Health concerns related to upper respiratory tract infections consisting of the common cold were also reported. The public also mentioned headaches, which were mostly associated with variability in climate.

6. Discussion

In this study, we examined perceptions of climate-related health risks in Ghana and how these perceptions vary between health experts and the general public. The findings of the study are discussed in the following order: 1) perceptions and knowledge of climate change and related health risks; 2) climate change health-related concerns; and 3) interrogating climate change health discourses.

6.1. Perceptions and knowledge of climate change and related health risks

Emerging from this research is an indication of limited knowledge of climate change and its related health risks. The results indicate that 26% of health experts and 44% of the public lacked knowledge of the underlying cause of climate change. This finding is not surprising, as it appears that the greatest misconception in public opinion about the concept of climate change relates to its underlying cause (see Read et al., 1994; Vignola et al., 2013). While there was not much difference between our study groups regarding knowledge of the underlying cause of climate change, health experts were more likely to link health-related risks to climate change compared to the public: perceiving it as a health threat. Health experts linking climate change to health have been reported in other studies (e.g., Paterson et al., 2012; Xiao et al., 2016). In addition, our study finding of the public not reporting a connection between climate change and health or not perceiving it as a health risk is consistent with prior studies in the United States, Canada and Malta (Akerlof et al., 2010; Leiserowitz, 2005). One plausible explanation for health experts' increased awareness of climate-related risk is that experts have a deeper understanding of climate change dynamics as they have more access to tools and methods to allow them to better evaluate the risks associated with climate change (Sundblad et al., 2009). Hansen et al. (2003) argued that scientifically trained experts tend to perceive environmental and health associated risks differently from the way lay-people perceive them. One obstacle to climate change knowledge is connected to the opportunities for obtaining firsthand information about scientific knowledge (Sundblad et al., 2009). According to Sundblad et al. (2009), experts have direct access to information in their own discipline, while laypersons are more dependent on information from other sources such as the media, which have been reported to contain misconceptions (Wilson, 2000). Thus, health experts relating climate change with health more frequently than the public could be accounted for by these issues, as they have more access to climate change related information through their disciplines and trainings.

Our findings also indicated that the objective knowledge measured (factual knowledge about the cause of climate change) was positively related to perceiving climate change as a health risk. Socio-demographic factors (compositional and contextual) were of varying degrees in terms of their association with climate change knowledge and perceiving climate-health risk among our study population. Compositional factors, gender, age and educational status were found to predict factual knowledge of the underlying cause of climate change. These factors have been reported in other studies as accounting for understandings and perceptions of climate change (e.g., Kahlor and Rosenthal, 2009; Lee et al., 2015; McCright, 2010). Gender, age, educational attainment and ethnicity were found to predict climate change health risk

perception among our study participants. From these findings, it emerged that while socio-demographic factors belonging to both the compositional and contextual dimension predicted climate change knowledge, the contextual factors examined were not associated with perceiving climate change as a health risk amongst our study population.

The findings show that factual climate change knowledge increased with higher educational attainment as it had a positive effect: respondents with a high level of education were more likely than their less educated counterparts to know the fundamental drivers of climate change. Educational attainment having a positive relationship on climate change knowledge has also been established in other studies (Kahlor and Rosenthal, 2009; Lee et al., 2015). Educational attainment seems to account for the gender differences seen in this study as well. Analysis revealed that males in our sample had higher levels of education compared to females especially amongst the community members. While 34% of males had no formal education, the percentage for females was 61% with only 6.5% of females having a tertiary education compared to 17% of males. Males possessing higher knowledge of climate change than females have been reported in other studies (e.g., Salehi et al., 2016).

Region of residence was found to have an association with factual knowledge about climate change. Individuals living within the Greater Accra region were found to have a higher chance of knowing the most important underlying cause of climate change. Within the Ghanaian context, there is a North-South dichotomy in relation to access to resources and development which has implications on other sectors. For example, while only 10 percent of the population in the Greater Accra region (southern sector) have never attended school, this figure was approximately 57 percent for the Northern region (northern sector). Furthermore, only 0.5 percent of the Northern Region population has a Bachelor's degree compared to a 4.5 percent of the population in Greater Accra region as of the last census of the country in 2010 (Ghana Statistical Service, 2012). This trend was replicated in the study sample especially at the community level with about 80 percent of respondents from the Savelugu-Nanton Municipal (Northern region) not having formal education compared to 9 percent in the Ga East District (Greater Accra region). This dichotomy in educational attainment could account for why the residents in the Greater Accra region have higher odds of knowing the fundamental cause of climate change. Education enhances ability to pick information from different sources and is reported to be positively related to systematic processing of information linked to scientific issues (Kahlor et al., 2006). Educational level functions as a socioeconomic divide, enables individuals with more education to have a greater capacity for integrating new information into pre-existing structures. Education also creates new knowledge structures as well as enabling individuals to have the trained capacity to follow certain issues such as climate change (Kahlor and Rosenthal, 2009).

Although region of residence was a significant predictor of climate change knowledge, place of residence was not. This finding has been reported elsewhere (Lee et al., 2015; Salehi et al., 2016). Lee et al. (2015) found rural/urban status not to be a key predictor among all countries. While rural/urban status was one of the key predictors in China, it was not an important predictor in the context of the United States.

Effect of age was found to vary based on different age groups. Age was a significant predictor for individuals aged 41–50 years and 61 years and above. Analysis revealed that individuals belonging to these age groups were predominantly engaged in agricultural activities. As farmers, most of them attributed the underlying driver of climate change to deforestation which is unsurprising, as deforestation plays a strong role in national climate change awareness programs in Ghana. As farmers, they are usually admonished on the need for afforestation as a mitigation measure. Thus, these age groups having factual knowledge compared to the others could be accounted for by this factor. A study in the Offinso municipality in Ghana reported that farmers perceived deforestation to be the cause of climate change and climate variability in their area (Odame Appiah et al., 2018).

6.2. Climate change related health risks

Climate change related health risks have been shown to be unique in different contexts, yet the diseases and health conditions attributed to climate change in our study are corroborated in previous studies (e.g. Akerlof et al., 2010; Olaris, 2008). For instance, Akerlof et al. (2010) in a qualitative study into perceptions of community members on health risks related to climate change reported that 22% of Canadians attributed respiratory diseases to climate change. In contextualizing strategies for managing the health risks of climate change, Costello et al. (2009) estimated a rise in prevalence of malaria and other infectious diseases such as floods and temperature rise becoming more rampant with increasing effects of climate change. Despite being consistent with the literature, most of the health risks reported among the general public stemmed from personal experiences with extreme weather and climate events. Exactly as to how the effects would manifest or be triggered could not be explained by some respondents in our study, which suggests limited knowledge about the underlying mechanisms linking climate variability to health risks in the Ghanaian context. As narratives on climate change-health risks are mostly based on exacerbated climatic trends and associated endemic diseases and health conditions (Costello et al., 2009), it is important to interpret findings from the public by counter-balancing with findings from health experts to provide deeper understating of climate change induced disease profiles in Ghana.

In addition, climate change has been acknowledged to facilitate growth of vector borne diseases (Berrang-Ford et al., 2009; De Casas and Carcavallo, 1995). It may not be surprising that most of the health concerns reported in our study involved vector borne diseases, and other more common health issues such as malaria. It is important to note that other well documented health effects of climate change such as air pollution and increasing allergens (e.g. respiratory allergies, asthma) and severe weather-related effects (injuries, fatalities, mental health impacts) were not reported in our study especially among the public. The probable explanation could be poor knowledge of the general public on climate change and its impacts on populations found in our study. Nonetheless, health experts reported an increasing prevalence of air pollution and asthma, indicating disparities in knowledge of climate change related health effects between health experts and the public.

6.3. Interrogating climate change health discourses

Our findings indicate that although discourses on climate change-health links from health experts and the public converge on basic knowledge of climate change, they diverge on the conceptualization of the underpinning factors driving climate change. Some subthemes are advanced more within a group or found only among one. An example is the ozone depletion subtheme, which was only described by the health experts. One other area of commonality in narratives was the reporting of climate variability and its subsequent relations to health risks.

The discourses however diverged in terms of the knowledge used in the conceptualizations. The narratives of the health experts were found to have some level of scientific underpinning, which was missing among most of the public. It was revealed that the public narratives were influenced by local knowledge, which was grounded in embodied experiences (Jackson and Neely, 2015). During data collection, it was found that there was no official focal point for climate change and health in Ghana. The WHO report on climate and health country profile for Ghana acknowledged this issue (WHO, 2016). Under national policy response, the country profile recommended a national focal point for climate change in the Ministry of Health. This lack of focal point or unit at the national level to advance climate change and health issues is

potentially contributing to low levels of knowledge on the subject at the local level. During interviews, most of the respondents indicated not receiving any education on climate change-health implications, even among some health experts. This could account for the pattern we saw in the quantitative analysis whereby 54% of the public did not perceive a link between climate change and health. Against this backdrop, health practitioners and physicians are being called upon to use their well-developed avenues of communication to raise awareness about the health aspects of climate change. The WHO calls for health professionals to take a leadership role in climate action planning (WHO, 2009).

There are limitations to this study that must be considered. Self-reported survey data may be influenced by respondent recall bias (Roser-Renouf et al., 2016). This study is restricted to two districts, and it is possible the reported knowledge and conceptualizations of climate change-health links might be different in other districts in Ghana. Nonetheless, the findings are generally consistent with the literature and provide significant basis for policies on climate change in Ghana. Based on knowledge about people's perceptions of climate change, its health risk component and the potential associated health risks, important inferences can be drawn which are useful both for the organization of communication and public awareness campaigns on these subjects, and for the design and implementation of relevant policies.

7. Conclusion

The findings of this study provide important insights into the different conceptualizations of climate change, its causes, and health impacts. Though studies have assessed perspectives on the health effects of climate change, none of the extant studies have looked at differences in how health experts and lay individuals or the public conceptualize climate change and its health linkages. Current studies have not explored the pathways by which the public and health experts link climate change to health (e.g. Akerlof et al., 2010; Cardwell and Elliott, 2013). This study has therefore shed light on the different discourses of climate change-health links and how health practitioners' understandings differ from the public. Thus, this research provides a better understanding of the mental models respondents used in processing and linking climate change with health. By characterizing these pathways from different groups in different geographical settings, this study responds to the call by Curtis and Oven (2012) for a more 'differentiated' perspective on the links between climate change and health, which explains the need to capture the diverse factors inducing health vulnerabilities and resilience to climate change of individuals and groups in different societies and different geographical settings.

Based on the current relatively inadequate climate change knowledge of our study group, more education is needed on climate change and its health implications within the country as a whole for both the public and health experts, which can be carried out by the government and civil society organizations. In addition, we recommend the development of climate change policy to embrace national and community level climate change health risk concerns. Such a policy would serve as a framework for developing, implementing and evaluating adaptation preparedness of local populations and health service providers. Lastly, findings also highlight that how groups experience and perceive climate change and its attendant risks are different, thus necessitating a nuanced and differentiated approach to health care provision and health promotion/communication in Ghana, and indeed similar contexts in the developing world such as sub-Saharan Africa.

Acknowledgement

We thank the health institutions for access and study participants for their valuable inputs into this research. The fieldwork aspect for this study was generously funded by the 2016 Association of American Geographers Dissertation Research Grant; The Queen Elizabeth II Diamond Jubilee Scholarship and the Faculty of Social Science Graduate Research Awards Funds- Western University. Funding from the University of Western Ontario's Faculty Directed Research Fund is also greatly appreciated. We also thank Hanson Nyantakyi- Frimpong for his thoughtful comments on an earlier draft of the paper. Finally, we are grateful to the anonymous reviewers whose critical and detailed comments helped to sharpen the quality of the paper.

References

Ada East District Assembly, 2018. Health. Retrieved on February 1, 2018 from. http://aeda.gov.gh/departments/health/.
Akerlof, K., Maibach, E.W., Fitzgerald, D., Cedeno, A.Y., Neuman, A., 2013. Do people "personally experience" global warming, and if so how, does it matter? Glob. Environ. Chang. 23 (1), 81–91.
Akerlof, K., DeBono, R., Berry, P., Leiserowitz, A., Roser-Renouf, C., Clarke, K.L., et al., 2010. Public perceptions of climate change as a human health risk: surveys of the United States, Canada and Malta. Int. J. Environ. Res. Publ. Health 7 (6), 2559–2606.
Asad, H., Carpenter, D.O., 2018. Effects of climate change on the spread of zika virus: a public health threat. Rev. Environ. Health 33 (1), 31–42.
Baptiste, A.K., 2017. Climate change knowledge, concerns, and behaviors among Caribbean Fishers. J. Environ. Soc. Sci. 1–12.
Berrang-Ford, L., MacLean, J.D., Gyorkos, T.W., Ford, J.D., Ogden, N.H., 2009. Climate Change and Malaria in Canada: a Systems Approach. Interdisciplinary Perspectives on Infectious Diseases. 2009.
Bryman, A., 2006. Integrating qualitative and quantitative research: how is it done? Qual. Res. 6, 97–113.
Bord, R.J., O'Connor, R.E., Fisher, A., 2000. In what sense does the public need to understand climate change? Publ. Understand. Sci. 9 (3), 205–218.
Capstick, S., Whitmarsh, L., Poortinga, W., Pidgeon, N., Upham, P., 2015. International trends in public perceptions of climate change over the past quarter century. Wiley Interdisciplin. Rev.: Climate Change 6 (1), 35–61.
Cardwell, F.S., Elliott, S.J., 2013. Making the links: do we connect climate change with health? A qualitative case study from Canada. BMC Public Health 13 (1), 208.
Collins, J., Ward, B.M., Snow, P., Kippen, S., Judd, F., 2017. Compositional, contextual, and collective community factors in mental health and well-being in Australian rural communities. Qual. Health Res. 27 (5), 677–687.
Costello, A., Abbas, M., Allen, A., Ball, S., Bell, S., Bellamy, R.,, et al., 2009. Managing the health effects of climate change: lancet and university college london institute for global health commission. Lancet 373 (9676), 1693–1733.
Creswell, J.W., 2014. Research Design: Qualitative, Quantitative, and Mixed Methods Approaches, fourth ed. Sage Publications, Thousand Oaks, CA.
Codjoe, S.N.A., Larbi, R.T., 2016. Climate change/variability and schistosomiasis transmission in Ga district, Ghana. Clim. Dev. 8 (1), 58–71.
Codjoe, S.N.A., Nabie, V.A., 2014. Climate change and cerebrospinal meningitis in the Ghanaian meningitis belt. Int. J. Environ. Res. Publ. Health 11 (7), 6923–6939.
Curtis, S.E., Oven, K.J., 2012. Geographies of health and climate change. Prog. Hum. Geogr. 36 (5), 654–666.
Dana, G.P.T., Roy, S., Haque, M.R., 2015. Adolescents perception on environmental change and health risk in two divisions of Bangladesh. Open J. Soc. Sci. 3 (12), 71.
De Casas, S.I.C., Carcavallo, R.U., 1995. Climate change and vector-borne diseases distribution. Soc. Sci. Med. 40 (11), 1437–1440.
Environmental Protection Agency (EPA) Ghana, 2012. Ghana's Second National Communication (GSNC) to the UNFCCC. United Nations Development Programme, New York, NY, USA.
Ermert, V., Fink, A.H., Morse, A.P., Paeth, H., 2012. The impact of regional climate change on malaria risk due to greenhouse forcing and land-use changes in tropical Africa. Environ. Health Perspect. 120 (1), 77.
Ghana Statistical Service (GSS) and ICF International, 2015. Ghana Demographic and Health Survey 2014. GSS, GHS, and ICF International, Rockville, Maryland, USA.
Ghana Statistical Service, 2014a. 2010 Population and Housing Census: District Analytical Report. Ghana Statistical Service, Ada East District. Accra, Ghana Retrieved from. http://www.statsghana.gov.gh/docfiles/2010_District_Report/Northern/SAVELUGU.pdf.
Ghana Statistical Service, 2014b. 2010 Population and Housing Census: District Analytical Report. Ghana Statistical Service, Savelugu-Nanton District. Accra, Ghana Retrieved from. http://www.statsghana.gov.gh/docfiles/2010_District_Report/Greater%20Accra/Ada%20East.pdf.
Ghana Statistical Service, 2012. 2010 Population and Housing Census: Summary Report of Final Results. Ghana Statistical Service, Accra, Ghana Retrieved from. http://www.statsghana.gov.gh/docfiles/2010phc/Census2010_Summary_report_of_final_results.pdf.
Hathaway, J., Maibach, E.W., 2018. Health implications of climate change: a Review of the literature about the perception of the public and health professionals. Curr. Environ. Health Rep. 1–8.
Haines, A., 2012. Sustainable policies to improve health and prevent climate change. Soc. Sci. Med. 74 (5), 680–683.
Hansen, J., Holm, L., Frewer, L., Robinson, P., Sandøe, P., 2003. Beyond the knowledge deficit: recent research into lay and expert attitudes to food risks. Appetite 41 (2), 111–121.
Hartter, J., Stampone, M.D., Ryan, S.J., Kirner, K., Chapman, C.A., Goldman, A., 2012. Patterns and perceptions of climate change in a biodiversity conservation hotspot. PLoS One 7 (2), e32408.

Helgeson, J., van der Linden, S., Chabay, I., 2012. The role of knowledge, learning and mental models in public perceptions of climate change related risks. In: Wals, A., Corcoran, P.B. (Eds.), Learning for Sustainability in Times of Accelerating Change. Wageningen Academic Publishers, Wageningen, NL, pp. 329–346.
IPCC, 2014. Climate Change 2014: Impacts. In: Barros, V.R., Field, C.B., Dokken, D.J., Mastrandrea, M.D., Mach, K.J., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.), Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge Unwersity Press, Cambridge, United Kingdom and New York, NY, USA, pp. 688.
Jackson, P., Neely, A.H., 2015. Triangulating health: toward a practice of a political ecology of health. Prog. Hum. Geogr. 39 (1), 47–64.
Kabir, M.I., Rahman, M.B., Smith, W., Lusha, M.A.F., Azim, S., Milton, A.H., 2016. Knowledge and perception about climate change and human health: findings from a baseline survey among vulnerable communities in Bangladesh. BMC Public Health 16 (1), 266.
Kahlor, L., Dunwoody, S., Griffin, R., Neuwirth, K., 2006. Predicting information seeking and processing in the context of impersonal risks. Sci. Commun. 28, 163–194.
Kahlor, L., Rosenthal, S., 2009. If we seek, do we learn? Predicting knowledge of global warming. Sci. Commun. 30 (3), 380–414.
Kellstedt, P.M., Zahran, S., Vedlitz, A., 2008. Personal efficacy, the information environment, and attitudes toward global warming and climate change in the United States. Risk Anal. 28 (1), 113–126.
Lee, T.M., Markowitz, E.M., Howe, P.D., Ko, C.Y., Leiserowitz, A.A., 2015. Predictors of public climate change awareness and risk perception around the world. Nat. Clim. Change 5 (11), 1014.
Leiserowitz, A.A., 2005. American risk perceptions: is climate change dangerous? Risk Anal. 25 (6), 1433–1442.
Luginaah, I., Arku, G., Baiden, P., 2010. Housing and Health in Ghana: the psychological impacts of renting a home. Int. J. Environ. Res. Publ. Health 7 (2), 528–545.
Maibach, E.W., Kreslake, J.M., Roser-Renouf, C., Rosenthal, S., Feinberg, G., Leiserowitz, A.A., 2015. Do Americans understand that global warming is harmful to human health? Evidence from a national survey. Annals of Global Health 81 (3), 396–409.
McCright, A.M., 2010. The effects of gender on climate change knowledge and concern in the American public. Popul. Environ. 32 (1), 66–87.
McSweeney, C., New, M., Lizcano, G., 2012. UNDP Climate Change Country Profiles: Ghana. Retrieved from. http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/index.html?country=Ghana&d1=Reports, Accessed date: 26 January 2018.
Milfont, T.L., 2012. The interplay between knowledge, perceived efficacy, and concern about global warming and climate change: a one-year longitudinal study. Risk Anal. 32 (6), 1003–1020.
Miles, M.B., Huberman, M., Saldana, J., 2014. Qualitative Data Analysis: A Methods Sourcebook. SAGE, Thousand Oaks.
O'connor, R.E., Bard, R.J., Fisher, A., 1999. Risk perceptions, general environmental beliefs, and willingness to address climate change. Risk Anal. 19 (3), 461–471.
Odame Appiah, D., Akondoh, A.C., Tabiri, R.K., Donkor, A.A., 2018. Smallholder farmers' insight on climate change in rural Ghana. Cogent Food Agric. 4 (1), 1436211.
Olaris, K., 2008. Community health services and climate change: exploring the sector's capacity to respond. Environ. Health 8 (2), 28.
Onwuegbuzie, A.J., Collins, K.M., 2007. A typology of mixed methods sampling designs in social science research. Qual. Rep. 12 (2), 281–316.
Paterson, J.A., Ford, J.D., Ford, L.B., Lesnikowski, A., Berry, P., Henderson, J., Heymann, J., 2012. Adaptation to climate change in the Ontario public health sector. BMC Public Health 12 (1), 452.
Pol, L.G., Thomas, R.K., 2013. Population composition. In: The Demography of Health and Healthcare. Springer, Dordrecht, pp. 65–89.
Read, D., Bostrom, A., Morgan, M.G., Fischhoff, B., Smuts, T., 1994. What do people know about global climate change? 2. Survey studies of educated laypeople. Risk Anal. 14 (6), 971–982.
Roser-Renouf, C., Maibach, E.W., Li, J., 2016. Adapting to the changing climate: an assessment of local health department preparations for climate change-related health threats, 2008-2012. PLoS One 11 (3), e0151558.
Rudiak-Gould, P., 2012. Progress, decline, and the public uptake of climate science. Publ. Understand. Sci. 23 (2), 142–156.
Salehi, S., Nejad, Z.P., Mahmoudi, H., Burkart, S., 2016. Knowledge of global climate change: view of Iranian university students. Int. Res. Geogr. Environ. Educ. 25 (3), 226–243.
Savelugu-Nanton Municipal Assembly, 2018. Composite Budget for 2018-2021: Programme Based Budget Estimates for 2018. Retrieved April 1, 2018 from. https://www.mofep.gov.gh/sites/default/files/composite-budget/2018/NR/Savelugu.pdf.
Shi, J., Visschers, V.H., Siegrist, M., Arvai, J., 2016. Knowledge as a driver of public perceptions about climate change reassessed. Nat. Clim. Change 6 (8), 759–762.
Stanturf, J.A., Warren, M.L., Charnley Jr., S., Polasky, S.C., Goodrick, S.L., Armah, F., Nyako, Y.A., 2011. Ghana Climate Change Vulnerability and Adaptation Assessment. United States Agency for International Development, Washington.
Sundblad, E.L., Biel, A., Gärling, T., 2007. Cognitive and affective risk judgments related to climate change. J. Environ. Psychol. 27, 97–106.
Sundblad, E.L., Biel, A., Gärling, T., 2009. Knowledge and confidence in knowledge about climate change among experts, journalists, politicians, and laypersons. Environ. Behav. 41 (2), 281–302.
van der Linden, S., 2015. The social-psychological determinants of climate change risk perceptions: towards a comprehensive model. J. Environ. Psychol. 41, 112–124.
van der Linden, S., 2017. Determinants and measurement of climate change risk perception, worry, and concern. In: Nisbet, M. (Ed.), The Oxford Encyclopedia of Climate Change Communication. Oxford University Press, Oxford. https://doi.org/10.1093/acrefore/9780190228620.013.318.
Vignola, R., Klinsky, S., Tam, J., McDaniels, T., 2013. Public perception, knowledge and policy support for mitigation and adaption to climate change in Costa Rica: comparisons with North American and European studies. Mitig. Adapt. Strategies Glob. Change 18 (3), 303–323.
Watts, N., Amann, M., Ayeb-Karlsson, S., Belesova, K., Bouley, T., Boykoff, M.,, et al., 2018. The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. Lancet 391 (2018), 581–630. https://doi.org/10.1016/S0140-6736(17)32464-9.
Weber, E.U., Stern, P.C., 2011. Public understanding of climate change in the United States. Am. Psychol. 66 (4), 315–328.
Wilson, K.M., 2000. Drought, debate, and uncertainty: measuring reporters' knowledge and ignorance about climate change. Publ. Understand. Sci. 9, 1–14.
Wolf, J., Moser, S.C., 2011. Individual understandings, perceptions, and engagement with climate change: insights from in-depth studies across the world. Wiley Interdisciplin. Rev.: Climate Change 2 (4), 547–569.
World Health Organization (WHO), 2016. Climate and Health Country Profile- 2015 Ghana. Retrieved from. http://apps.who.int/iris/bitstream/10665/208862/1/WHO_FWC_PHE_EPE_15.08_eng.pdf?ua=1.
World Health Organization (WHO), 2014. Quantitative Risk Assessment of the Effects of Climate Change on Selected Causes of Death, 2030s and 2050s. Switzerland, Geneva.
World Health Organization, 2009. Protecting Health from Climate Change: Connecting Science, Policy and People Geneva: World Health Organization. Retrieved from. www.who.int/globalchange/publications/reports/9789241598880/en/index.html.
World Health Organization, 2008. World Health Day 2008: Protecting Health from Climate Change. World Health Organization, Geneva Retrieved from. http://www.who.int/world-health-day/toolkit/report_web.pdf.
Xiao, J., Fan, W., Deng, Y., Li, S., Yan, P., 2016. Nurses' knowledge and attitudes regarding potential impacts of climate change on public health in central of China. Int. J. Nurs. Sci. 3 (2), 158–161.
Yu, H., Wang, B., Zhang, Y.J., Wang, S., Wei, Y.M., 2013. Public perception of climate change in China: results from the questionnaire survey. Nat. Hazards 69 (1), 459–472.